Research Article

THE EFFECTS OF MULTIMEDIA INQUIRY-BASED LEARNING ON MATHEMATICS LEARNING ACHIEVEMENT FOR GRADE FIVE BHUTANESE STUDENTS

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ABSTRACT

This study investigated the effects of Multimedia Inquiry-Based Learning on mathematics learning achievement for grade five Bhutanese students. The study was conducted with a sample group selected through a clustered random sampling method from a school in Thimphu, Bhutan. This study employed a mixed-methods research design. A total of 32 students participated, utilizing four lesson plans, achievement tests (pre-test and post-test), and semi-structured interviews for data collection. Quantitative data from the tests were analyzed using a paired sample t-test, which revealed a significant increase in posttest scores ($\bar{X}$ = 15.25) compared to pretest scores ($\bar{X}$ = 10.75), resulting in a mean difference of 4.5. Additionally, qualitative data obtained from semi-structured interviews indicated that students were delighted with the learning experience. Hence, the findings suggested that multimedia inquiry-based learning significantly enhanced students' mathematics achievement, providing educators with an effective approach for teaching fractions.

Keywords : Grade five Students, Inquiry-based learning, Learning Achievement, Multimedia

1. INTRODUCTION

In Bhutan, mathematics is a compulsory subject from pre-primary through grade ten; however, there is a significant lack of student interest. This widespread issue adversely affects academic performance and career choices, as many students perceive mathematics as difficult and irrelevant (Boaler, 2016). The 2022 grade six assessment results from the Bhutan Council for School Examination and Assessment revealed that Mathematics (69.56%) and Science (68.06%) had the lowest average scores, while English scored highest at 91.69%. This trend of low performance in Mathematics has persisted in national examinations (Rinzin, 2021). In response, His Majesty the

King of Bhutan issued a Royal Kasho to reform STEM education, focusing on modernizing curricula, enhancing teacher training, and integrating technology and experiential learning (The Bhutanese, 2021).

National examinations by the Bhutan Council for School Examinations and Assessment revealed that Bhutanese students struggle significantly with fractions due to their abstract nature and connections to ratios and decimals. This inadequate foundation adversely affects overall math achievement (Siegler et al., 2011). Language barriers further complicated matters, as many students find it challenging to understand English mathematical terminology (Dorji, 2022). Additionally, math anxiety and low self-confidence hinder performance (Gyeltshen & Wangdi, 2021). Inquiry-based learning (IBL) addresses these issues by promoting exploration and problem-solving, enhancing student engagement and understanding of challenging concepts like fractions (Swan, 2006).

This study investigated the integration of multimedia and inquiry-based learning to improve mathematics instruction for grade five Bhutanese students. Multimedia tools, such as instructional videos and PowerPoint, promoted student-centered learning and enabled knowledge construction through questioning and investigation. Lessons used multimedia resources within the inquiry cycle, allowing students to address real-life problems and analyze data collaboratively or individually. Teachers facilitated critical thinking, while multimedia increased accessibility and interactivity.

Effectively utilizing PowerPoint (PPT) and multimedia consisted of five essential steps based on the 5E model. In the Engage phase, begin with vibrant PPT slides that present real-life examples or thought-provoking questions, complemented by a brief video to stimulate curiosity. During the Explore phase, use PPT to introduce tasks while incorporating interactive tools like GeoGebra or Desmos, enabling hands-on exploration. In the Explain phase, present key concepts clearly and enhance comprehension by using videos or animations to simplify complex ideas. In the Elaborate phase, challenge students with higher-order questions and real-world problems through PPT, along with interactive exercises. Finally, in the Evaluate phase, assess understanding through quizzes or additional problem-solving tasks. This cohesive approach combines visual, auditory, and interactive elements, fostering deeper understanding and improving knowledge retention.

In Bhutanese classrooms, the 5E model offers an effective alternative to traditional rote memorization by promoting critical thinking (Wangmo & Jamtsho, 2021). Incorporating multimedia during the Engage and Explore phases enhances student motivation and makes complex mathematical concepts more accessible (Sari et al., 2020). Evidence showed that this integration boosts long-term retention and confidence in applying knowledge (Yildirim, 2020). Multimedia enriches the exploration phase of the 5E model, using tools like PowerPoint for definitions and videos for problem-solving methods and real-world applications of fractions (Heryanto et al., 2023).

2. RESEARCH OBJECTIVES

This study aimed to investigate the effects of multimedia inquiry-based learning on mathematics learning achievement for grade five Bhutanese students by addressing the following objectives:

2.1 To investigate the effect of multimedia inquiry-based learning on grade five Bhutanese students' learning achievement in mathematics.

2.2 To examine grade five Bhutanese students' satisfaction towards using multimedia inquiry-based learning for learning mathematics.

3. SCOPE OF THE STUDY

The study focused on grade five students at Changzamtog Middle Secondary School in Thimphu, Bhutan, which also serves those with Special Educational Needs (SEN). It involved 125 students aged 11 to 13 across four sections, from which 32 were selected using cluster random sampling. The research included eight different 90-minute class sessions on Fractions from late April to mid-May, following guidelines from the Royal Education Council (REC). A *pre-test* was given before instruction, and a *post-test* afterward to assess the teaching approach's effectiveness.

4. RESEARCH QUESTIONS

4.1 Were there any effects on grade five Bhutanese students' learning achievement in mathematics by using inquiry-based learning and multimedia?

4.2 Did grade five Bhutanese students exhibit satisfaction towards using inquiry-based learning and multimedia for learning mathematics?

5. CONCEPTUAL FRAMEWORK OF THE STUDY

This study clearly defined two sets of variables: independent and dependent. The independent variables were the effects of Multimedia Inquiry-Based Learning in teaching fractions, while the dependent variables were the mathematics learning achievements and students' learning satisfaction with these approaches.

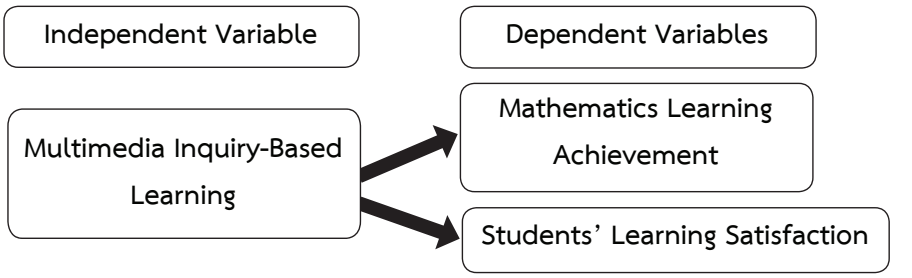

Figure 1: Independent and Dependent Variables.

6. RESEARCH METHODOLOGY

6.1 Research Design

This study used a mixed-methods approach to explore the mathematics achievement and satisfaction of Grade Five students in Bhutan regarding multimedia inquiry-based learning.

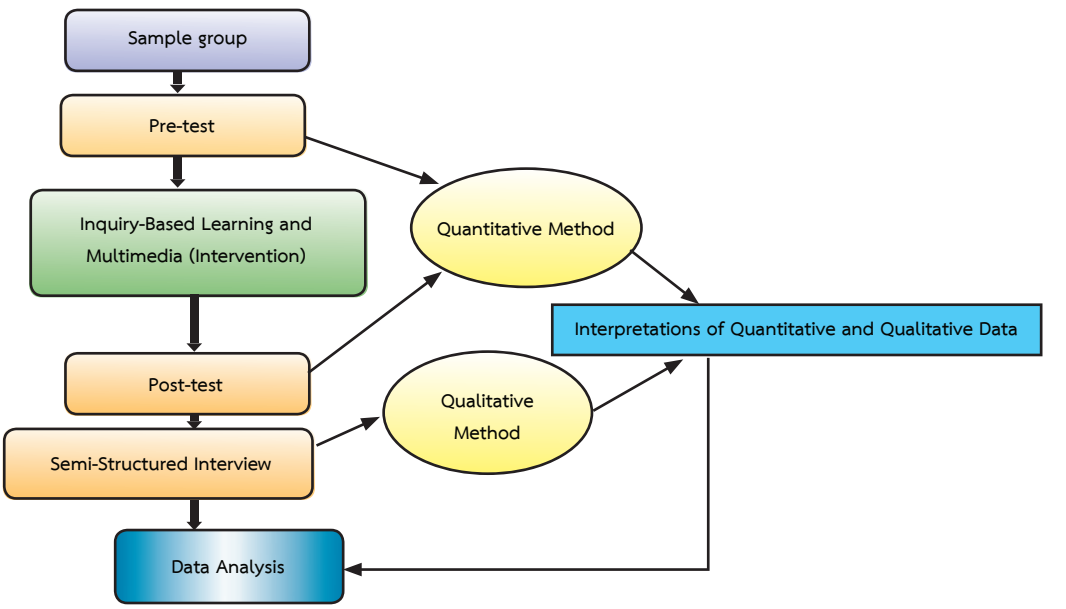

Figure 2: Research Design of the Study

6.2 Research Instruments

In this study, the researcher utilized three instruments to collect data from grade five Bhutanese students: lesson plans, pre-test and post-test achievement tests, and semi-structured interviews. Four different 90-minute lessons focused on teaching the concept of fractions over

four weeks, combining multimedia and inquiry-based learning strategies using tools like PowerPoint presentations, worksheets, and short video clips. To evaluate student progress, a mathematics learning achievement test featuring the same content in a different order was administered before and after the intervention. This test included five multiple-choice questions, five true/false questions, and six short-answer questions, totaling 20 marks. Post-intervention, semi-structured interviews lasting three to five minutes were conducted to assess students' satisfaction with the multimedia approach. Interviews were recorded, and students could respond in English or Dzongkha. The researcher translated and transcribed responses for thematic analysis, allowing for an in-depth exploration of the identified themes.

6.3 Data Analysis

The analysis consisted of two distinct parts. The first part utilized quantitative data from pre-tests and post-tests to address research question one, employing paired sample *t*-tests to calculate the mean, standard deviation, and significance values for comparative analysis. The second part focuses on qualitative data gathered from semi-structured interviews with 28 out of 32 volunteer students, conducted after the intervention, and analyzed through content analysis to answer research question two. To ensure participant anonymity, the same identification codes used during the testing phases were maintained.

6.4 Reliability and Validity

In this study, validation was performed by three experts: a professor from Thailand and two experienced educators from Bhutan. The research instruments included lesson plans, test items, and semi-structured interview questions, evaluated using the Item Objective Congruence Index (IOC). Items with scores of 0.67 and above were deemed acceptable, while those below indicated areas for improvement. All instruments achieved ratings of 0.67 or greater, with lesson plans and assessment questions receiving an exceptional IOC rating of +1. Reliability, crucial for trustworthiness, was tested through a pilot study with 30 grade six students, using the Kuder-Richardson formula (KR-20). The pilot test resulted in a reliability coefficient of 0.75, confirming the reliability of the test items.

6.5 Ethical Considerations

The researcher received approval from the Research and Development Institute at Rangsit University and obtained consent from the Ministry of Education and Skills Development in Bhutan, the Chief Thromde Education Officer, the Principal, the relevant department head, and the subject teacher prior to the commencement of data collection. Given that the participants were minors, parental consent was sought, ensuring that parents were informed and understood the consent letter. This procedure was designed to safeguard the rights of all research participants

throughout the study. Rigorous measures were employed to maintain the confidentiality and anonymity of participants' information, with identification conducted solely via assigned numbers (e.g., Student 01, Student 02) to further protect their privacy. This protocol was communicated to the students before the initiation of the research.

7. RESEARCH RESULTS

7.1 Quantitative data analysis of learning achievement

Quantitative data were collected using pre-tests and post-tests to evaluate the learning achievement levels of students following the implementation of instructional interventions in mathematics. The assessments comprised 20 questions, including 5 multiple-choice, 5 true/false, and 6 short-answer items, administered to a sample of 32 grade five students in Bhutan. To assess the effectiveness of multimedia inquiry-based learning, a paired sample *t*-test was conducted to analyze the differences between pre-test and post-test scores. Additionally, a comparative statistical analysis was performed, incorporating measures such as mean, standard deviation, and significance value (*p*-value) to ensure the rigor of findings.

Table 1 Paired sample *t*-Test analysis of pre-test and post-test within the sample group.

Group	Pre-test		Post-test		Mean Difference	*t*	p-value
	M	SD	M	SD			
Sample Group	10.75	2.73	15.25	2.82	4.5	12.35	0.01

Table 1 presents the results of the paired sample *t*-test assessing learning achievement test scores in a sample group before and after the intervention. The pre-test mean score was 10.75, and the post-test mean score was 15.25, with a mean difference of 4.5. The significance value, 0.01, further demonstrated the statistical relevance of the findings. The standard deviations for the pre-test and post-test were 2.73 and 2.82, respectively. These results suggested that multimedia inquiry-based learning positively affected mathematical achievement among grade five Bhutanese students.

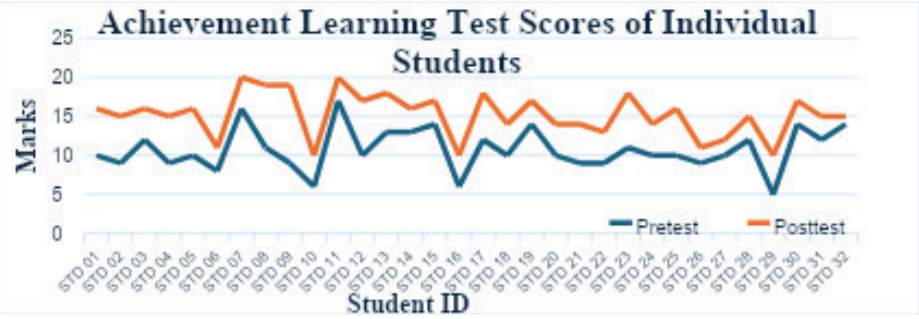

Figure 3: Individual student learning achievement scores in Pre-test and Post-test

Figure 3 illustrates the mathematics achievement scores of individual students in both the pre-test (represented by the blue line) and the post-test (represented by the orange line). The gap between these lines reflects the degree of improvement each participant made after the intervention. The data indicate that all participants demonstrated significantly better performance in the post-test compared to the pre-test, underscoring the positive impact of the intervention.

7.2 Qualitative data analysis of students' learning satisfaction

A semi-structured interview approach was employed to collect qualitative data about students' satisfaction with multimedia inquiry-based learning in mathematics. After the intervention, a total of 28 out of 32 students volunteered to participate in the interviews. To ensure participant anonymity, the same identification codes utilized during the pretest and posttest phases were retained. The interview protocol, consisting of five rigorously validated questions, was designed to evaluate various dimensions, including students' experiences, learning outcomes, motivation, the effects of collaborative learning strategies, and engagement levels with multimedia tools such as PowerPoint presentations and videos.

(1) Experience

Student feedback suggests that this intervention introduced a novel approach to learning mathematics. Traditionally, students have relied on rote memorization and repetitive exercises, concentrating on procedural skills rather than conceptual understanding.

"We usually learn mathematics where teachers write on the whiteboard, explain it, give us more exercises to do, and sometimes show some videos related to the topic." (Student 19)

"Sir explains a topic and writes it on the board, gives us more questions, and sometimes we do group work too." (Student 27)

(2) Learning Achievement

Students remarked that the multimedia inquiry-based learning profoundly transformed their educational experience. This approach shifted their focus from passive memorization to active exploration, allowing them to understand concepts more deeply and making lessons more engaging. Many highlighted that multimedia tools, such as videos and visual representations, clarified complex topics and enhanced their appeal. As a result, this method not only improved their performance and retention but also nurtured greater confidence and curiosity in mathematics.

"Yes, I agree. The multimedia videos and animations in PPT helped me visualize how everything worked, especially fractions. It was way easier to see it in action." (Student 15)

"For me, it also made class more fun. Instead of just listening to teachers, we got to experiment and discover things ourselves. It kept me interested and helped me remember the concept better." (Student 03)

(3) Motivation

Students indicated that multimedia inquiry-based learning significantly boosted their engagement in class. They highlighted how inquiry fostered curiosity and exploration, transforming mathematics from a dull subject into an exciting challenge. Tools such as videos, activities, and animations brought lessons to life, simplifying complex topics. Many students remarked that these strategies cultivated a vibrant and enjoyable classroom environment, encouraging them to express their thoughts and collaborate with their peers.

"Yes, I was more motivated to participate in the class when using inquiry-based learning and multimedia, as it makes learning more fun and easier to understand." (Student 11)

(4) Collaborative Learning Impact

The impact of collaborative learning, as evidenced by semi-structured interview responses, revealed a spectrum of positive student experiences. Numerous respondents expressed a strong affinity for collaborative learning; for instance, one student remarked, "I enjoyed discussing problems with my friends; it significantly enhanced my understanding" (Student 02). Another noted, "We were able to help each other" (Student 12), while a third stated, "We get different ways to learn mathematics, and we can improve our communicative skills too" (Student 04). These insights underscore the advantages of collaborative learning, including enhanced comprehension and a more engaging educational environment.

(5) Engagement and Interest

Students demonstrated a clear preference for multimedia tools, including PowerPoint presentations and videos, compared to traditional pedagogical approaches. These

tools were noted to significantly enhance visual engagement and facilitate a deeper understanding of complex subjects by illustrating real-world applications of theoretical concepts. In contrast to conventional lectures and textbook readings, the incorporation of multimedia resources promoted an interactive educational experience that mitigated the monotony often associated with traditional learning. Ultimately, students recognized that the integration of visual, auditory, and interactive elements enriched their educational experiences, rendering them more memorable and enjoyable.

"Yes, I did find PPT and video lessons more engaging than traditional lessons, as it's more interesting and it encouraged me to learn more." (Student 13)

Yes, it's more fun and engaging with PPTs and videos as we understand more. Usually, the videos are animated and more understandable. (Student 09)

8. DISCUSSION

This research aimed to explore two primary questions: the enhancement of mathematics achievements among Grade five students in Bhutan and their satisfaction with the implementation of multimedia inquiry-based learning in the classroom. The study examined how these innovative pedagogical strategies influenced both student learning outcomes and their overall satisfaction with the teaching methods employed.

This study explored the effects of multimedia inquiry-based learning on the mathematics performance of grade five students in Bhutan. The results indicated a significant improvement, with average post-test scores (15.25) markedly higher than pre-test scores (10.75), resulting in a mean increase of 4.5 points. The majority of students achieved higher scores on the post-test, suggesting that integrating multimedia inquiry-based learning is an effective pedagogical approach for enhancing students' mathematical achievement.

A comparative analysis of student learning outcomes indicated significant progress among both high-achieving and previously struggling students when inquiry-based learning (IBL) was integrated with multimedia resources, particularly PowerPoint and videos, in grade five fraction instruction. Naidoo and Hajaree (2021) conducted a study featuring two PowerPoint presentations with instructional videos that promoted collaborative inquiry-driven lessons. This approach facilitated small-group discussions, deepened understanding of fraction concepts, and resulted in improved accuracy on follow-up tasks. Classroom observations revealed that students found the multimedia scaffolding made learning fractions more enjoyable and memorable. Additionally, students expressed high satisfaction with the IBL and multimedia integration, reporting enhanced engagement and meaningfulness in their learning experiences. This aligns with Naidoo and Hajaree's

findings that students described their experiences as “fun” and “helpful” for understanding fractions. Collaborative group work during inquiry activities fostered a supportive learning environment, simplifying complex concepts and bolstering students’ confidence in their mathematical reasoning skills.

This study highlighted a notable level of student satisfaction with mathematics instruction delivered through inquiry-based learning (IBL) with multimedia. Students reported that using PowerPoint and video tools to explore fractions was effective, enjoyable, and motivating. These findings aligned with Hsu et al. (2025), who observed that multimedia-supported IBL provides immediate feedback and fosters collaboration, resulting in a deeper understanding of mathematical concepts.

9. CONCLUSION

In conclusion, the study revealed that multimedia inquiry-based learning significantly improved the mathematics achievement of grade five Bhutanese students, with a mean score difference of 4.5 between the pre-test and post-test. Interviews indicated that students found these methods engaging and relevant, with multimedia resources enhancing their understanding and retention of mathematical concepts. Overall, this approach positively impacted students’ attitudes, motivation, and academic performance in mathematics.

10. RECOMMENDATIONS

Recommendations for future research

1. This study examined the effects of inquiry-based learning (IBL) and multimedia within mathematics instruction for Grade Five Bhutanese students. Although the findings are specific to this population, the methodologies employed suggest potential applicability across various educational contexts and subject areas. Future research should investigate the effectiveness of this approach in diverse settings to validate and extend these initial findings.

2. The duration of this study was limited to one month, which restricts the depth of insights. Therefore, extending the timeframe for future studies may yield more comprehensive evidence regarding the long-term impacts of IBL and multimedia integration in mathematics education.

3. Furthermore, the study utilized a single-group pretest-posttest design; future investigations would benefit from the inclusion of experimental and control groups to facilitate a more rigorous comparative analysis of instructional methods.

4. The multimedia resources employed in this study were confined to PowerPoint presentations and educational videos. Subsequent research should encompass a broader array of multimedia tools, such as animations and interactive simulations, to assess their effectiveness in enhancing students' mathematical understanding.

5. While this research focused on the primary education level, analogous studies at secondary or higher educational levels could provide valuable insights into the scalability and overall effectiveness of this pedagogical approach.

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